EPC®-21/22

Hardware Reference

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NOTES

1. Product Description

The EPC-21 and EPC-22 are PC/AT compatible CPU modules in a very small form factor (3" x 5.9") based on the Intel386 SL chip set. These EPCs have been designed to meet stringent safety and low EMI standards (UL-1950). All front panel accessible ports have filter networks for reduced EMI and increased ESD protection.

Throughout this manual, the term EPC is used to designate both the EPC-21 and the EPC-22. Where necessary, differences between the EPC-21 and EPC-22 are specified separately.

Each processor module contains the following:

- The EPC-21 contains a 16 MHz Intel386 SL processor
- The EPC-22 contains a 25 MHz Intel386 SL processor and an 80387SX math coprocessor
- The EPC-22 contains 64 Kbytes of SRAM cache
- Up to 20 MBytes of DRAM memory
- Keyboard interface
- 1 standard 9-pin DTE serial port (COM1)
- 1 RJ-45 serial port (COM2)
- Time-of-day clock with user replaceable battery
- Award BIOS
- Watchdog Timer
- EXM expansion interface (electrically similar to the 16-bit PC/AT ISA bus)

1 1

Specifications

Environmental		
Temperature	operating	0° to 60° C (* see below)
	storage	-40° to 125° C
Humidity	operating	0 - 95% (non-condensing)
	storage	0 - 95% (non-condensing)
Vibration	operating	.015"PP 2.5g (max) 5-2000 Hz
	storage	.030"PP 5g (max) 5-2000 Hz
Shock	operating	30g 11 msec duration
	storage	50g 11 msec duration
Electrical		
EPC-21	maximum	+5V @ 850 mA
	typical	+5V @ 650 mA
EPC-22	maximum	+5V @ 1.25 A
	typical	+5V @ 1.1 A

* Upper temperature limit degrades 2° C per 1000 ft. elevation. Maximum elevation 10,000 ft.

See Appendix A for mechanical dimensions.

2. Configuring the BIOS Setup

2 2

Power-On Screen Display

Whenever a hardware reset of the EPC occurs (power-on or front panel reset), the system performs a power-on self-test (POST) which will display information showing the status of the BIOS self test if a monitor is attached via a video adapter. If everything proceeds normally, the screen image will appear approximately as shown below.

```
386SL Modular BIOS V3.06abd.
Copyright (c) 1984-90 Award Software Inc.
Copyright 1992 RadiSys Corporation  BIOS V3.06

TESTING INTERRUPT CONTROLLER #1 .....OK
TESTING INTERRUPT CONTROLLER #2 .....OK
TESTING CMOS BATTERY  .....OK
TESTING CMOS CHECKSUM  .....OK
SIZING SYSTEM MEMORY  ..... 640K FOUND
TESTING SYSTEM MEMORY  ..... 640K OK
CHECKING UNEXPECTED INTERRUPTS AND STUCK NMI  .....OK
TESTING PROTECTED MODE  .....OK
SIZING EXPANSION MEMORY  ..... 3072K FOUND
TESTING MEMORY IN PROTECTED MODE  ..... 3712K FOUND
TESTING PROCESSOR EXCEPTION INTERRUPTS  .....OK
TESTING ONBOARD SERIAL PORT #1  .....OK
TESTING ONBOARD SERIAL PORT #2  .....OK

RadiSys EPC Setup Program
```

The values shown in the two lines `SIZING EXPANSION MEMORY` and `TESTING MEMORY IN PROTECTED MODE` may be different than shown above depending on the memory configuration of each system.

2 2

If errors occur during the power-on self-test, the BIOS will display the error on the appropriate line of the screen display and attempt to continue. For instance, if a failure is discovered in COM1, the BIOS will disable COM1, display the error on the line "TESTING ONBOARD SERIAL PORT #1 ....." and then continue as if the error did not occur. It is important to watch the POST display to verify that no errors occur.

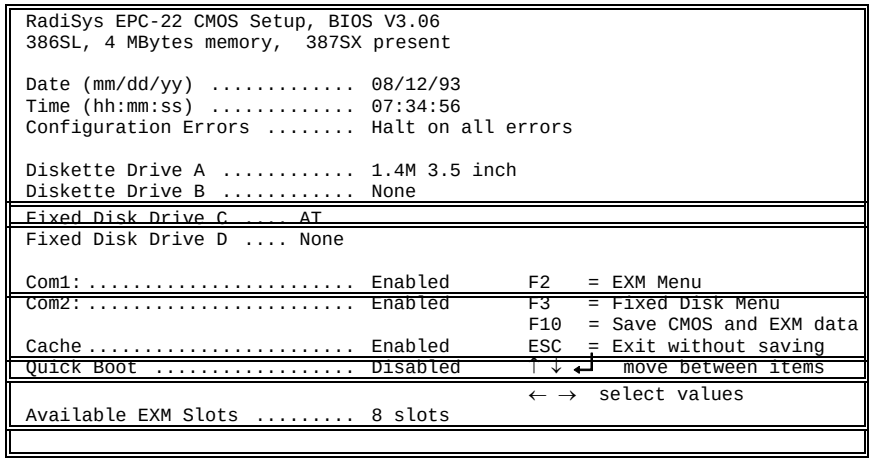
If error messages are displayed during or after the POST display, see chapter 5, *Troubleshooting & Error Messages* on page 27.

BIOS Setup Screen

The EPC-21/22 BIOS contains a setup function to display and alter the system configuration. This configuration information is maintained in the EPC's battery-backed CMOS RAM and is used by the BIOS to initialize the EPC's hardware.

The setup function can be invoked any time after the POST completes and first clears the screen. Simultaneously press the CTRL+ALT+ESC keys. This may be done during system operation in most, but not all circumstances. Some programs that take control of the keyboard at a low level, such as Microsoft Windows, cause this key sequence to be interpreted differently, or not at all. It should always work, however, when the DOS operating system prompt is shown on the screen.

The main setup screen resembles the following:


RadiSys EPC-22 CMOS Setup, BIOS V3.06
386SL, 4 MBytes memory, 387SX present
Date (mm/dd/yy) 08/12/93
Time (hh:mm:ss) 07:34:56
Configuration Errors ..... Halt on all errors
Diskette Drive A ..... 1.4M 3.5 inch
Diskette Drive B ..... None
Fixed Disk Drive C .... AT
Fixed Disk Drive D .... None
Com1: ..... Enabled
Com2: ..... Enabled
Cache ..... Enabled
Quick Boot ..... Disabled
Available EXM Slots ..... 8 slots
F2 = EXM Menu
F3 = Fixed Disk Menu
F10 = Save CMOS and EXM data
ESC = Exit without saving
↑ ↓ ↵ move between items
← → select values

Use the up and down cursor (arrow) keys to move from field to field. For most fields, once the cursor is positioned at the field, pressing the left and right cursor (arrow) keys will scroll through the available choices. Once the screen has been changed to appear as you desire, press the F10 function key to save the changes in battery-backed CMOS RAM. Then press the F5 function key to confirm the changes and reboot, F1 to confirm changes but not reboot or ESC to ignore any changes and exit.

Each field is explained below.

Date and Time

These values are changed by moving to them and typing in the format shown.

Configuration Errors

This field provides several choices about the situations under which the BIOS should wait for user input if a configuration error is found. The selections are:

1) Halt on all errors
2) Ignore all errors
3) Ignore keyboard errors (allows operation without a keyboard)
4) Ignore disk errors
5) Ignore keyboard and disk errors

Diskette Drive

This field gives you several choices about the type of floppy disk drives installed as the A and B drives. Toggle the entry to match the type of diskette drive(s) attached. If no floppy drive is attached, select NONE for each diskette drive field.

Fixed Disk Drive

This display-only field shows the type of disk selected from the fixed disk menu. Possible values are None, AT and EXM FLASH. To see the detailed characteristics of the device or to change the device, use the F3 function key to go to the fixed disk menu. See the section *Fixed Disk Menu,* page 7.

Com1:
Com2:

Toggling these fields enables or disables the Com1 or Com2 ports.

Cache

This field is valid only on the EPC-22. Toggling this field enables or disables the on-board SRAM cache.

Available EXM Slots

Use the arrow keys to change the displayed number of available EXM slots, or card cage connectors, in the system's backplane. To determine the correct number of available EXM slots, count the **total** number of EXM card edge connectors in the system's backplane.

As a "worst case" configuration example, if an eight-slot backplane is accidentally set for only four slots, all EXMs above that fourth slot will not configure. (The only exception is the video card, which auto-enables to allow for error recovery.) Continuing with this example, the system would not boot if the boot device was located above the fourth slot. Information is cleared for the missing four slots, and must be re-entered once the number of slots is corrected.

EXM Setup Screen

This screen is only of significance if the system contains EXM expansion modules.

The EXM setup screen is used to configure EXM expansion modules in the system. It is displayed by pressing the F2 function key from the main setup screen. The EPC's battery-backed RAM holds the identification and configuration information for the number of available EXM slots entered in the EXM Main Setup Screen. The BIOS displays the configuration information in hexadecimal format. The EXM Setup screen for a system with an eight-slot backplane, a six-slot chassis, an EMC-FDM in slots 6 and 7, and an EPC-22 in slot 0 might resemble the following:

```
RadiSys EPC-22 EXM Setup, System BIOS V3.06
386SL, 4 MBytes memory,  387SX present

 0      FF     00     00
 1      ED     01     00                F10 = Save and return
 2      7D     07     00                ESC = Return without saving
 3      DB     C1     00
 4      D5     C1     00                 ↑ ↓ ← → move between items
 5      DE     00     39
 6      7C     FF     FF
 7      FF     00     00

  ID is the unique EXM-ID number.
  OB1 and OB2 are option bytes 1 and 2.

  The option bytes interpretation is unique to each EXM-ID.
  See the EXM user manuals for the semantics of the option bytes.
```

EXMs must be defined in this screen so the BIOS can correctly identify and initialize each one at boot-up. Each EXM must be listed by slot number, ID and two option bytes as defined below.

SLOT	indicates the EXM slot in which the EXM is installed.
ID	is a hard-wired identification value. Each type of EXM has a unique ID value.
OB1/OB2	are two "option" bytes of configuration information.

All slots **not** occupied by an EXM module should show an ID of FF indicating that no EXM is present.

Consult the EXM manual for the correct configuration information for each EXM expansion module installed.

After all EXMs have been configured, press F10 to save the data or ESC to ignore the changes. In either case you will be returned to the main setup screen.

Fixed Disk Menu

The Fixed Disk Menu is used to define the type of hard disk(s) installed in the system. Enter the Fixed disk menu screen by pressing the F3 function key from the main setup screen.

2 2

The Fixed disk menu screen resembles the following:

```
RadiSys EPC-22 Fixed Disk Menu, System BIOS V3.06
386SL, 4 MBytes memory,  387SX present

 Fixed Disk Drive C:  AT
     Type  40          115 MBytes:  814 Cyls,    9 Heads, 32 Sectors
                        Landing Zone: 1023         Precompensation: None

 Fixed Disk Drive D: None

                                                F10 = Save and return
                                                ESC = Return without saving
                                                ↑ ↓  ↵ move between items
                                                ← → select values
```

Use the up and down cursor keys (↑ ↓) to move between items. Use the left and right cursor keys (← →) to scroll through the available choices for each item.

Disk type **AT** denotes the many types of non-SCSI PC/AT compatible drives including IDE. You can scroll through a set of numbered types; the physical configuration is displayed for each. Scroll through the numeric drive types to find the one matching the characteristics of the hard drive installed.

Choose disk type **EXM Flash** if you are using an EXM flash disk. An EXM flash disk can be made the boot device by making EXM Flash the drive C: type. However, if Drive C: is EXM Flash, Drive D: must be set to None.

Choose **None** if there is no hard disk present. This avoids the timeout period used by the BIOS to conclude that there is no responding device.

User-Definable Drive Types

If the correct **AT** disk type is not listed, the EPC provides user-editable drive types 48 and 49. Select either of these drive types. Use the TAB key (→|)or the left and right cursor keys (← →) to move to the next (or previous) field. Note that the default settings for MBytes, Cylinders, Heads, and Sectors is 1. MBytes is a display-only field calculated by the BIOS. Move the cursor to each field (Cyls, Heads, and Sectors) and type the value for that field.

The BIOS allows use of the following maximum values:

Cylinders 1023 Heads 63 Sectors 16

The hard disk you are using may have parameters larger than the allowable maximum. If the number of cylinders for your drive is greater than the maximum allowable number, you may have to use 1023 cylinders which will limit the usable size of the drive. However, most IDE drives support universal translation mode. If the drive you are using supports this mode and the actual parameters are greater than the allowable maximum, divide the actual number of cylinders by 2 and multiply the actual number of heads by 2. That is, each sector is addressed as an absolute sequential sector number. Since the drive converts the sector data to an absolute number, these "false" cylinder and head numbers will still allow the full capacity of the drive to be used. The example on the next page shows how this is done.

Example:

	Actual parameters	Conversion factor	Numbers to Use
Cylinders	1350	divide by 2	675
Heads	5	multiply by 2	10
Sectors	32	(none)	32
Total Sectors	216,000		216,000

After the fixed disk(s) have been configured, press F10 to save the data or ESC to ignore the changes. In either case you will be returned to the main setup screen. Follow the instructions on the screen to save and exit or ignore changes and exit.

NOTES

3. Theory of Operation

The EPC-21 and EPC-22 are PC/AT compatible processor modules. The standard functions of the PC architecture are embodied in the Intel386 SL chip set. Unless otherwise stated, all the following applies to both the EPC-21 and EPC-22.

Processor and Coprocessor

The EPC uses the Intel386 SL CPU.

The EPC-21 runs at 16 MHz without a cache. There is no math coprocessor nor coprocessor socket.

The EPC-22 runs at 25 MHz with a 64K SRAM cache and includes an Intel 80387SX math coprocessor. Note that this is **not** a socketed part.

Memory

Each EPC has a base memory configuration of 1 MByte or 4 Mbytes soldered on the motherboard. This memory is arranged as 2 banks (banks 0 and 1) of memory chips located at locations U12 and U13 on the upper rear corner of the circuit board. See Figure 1 below.

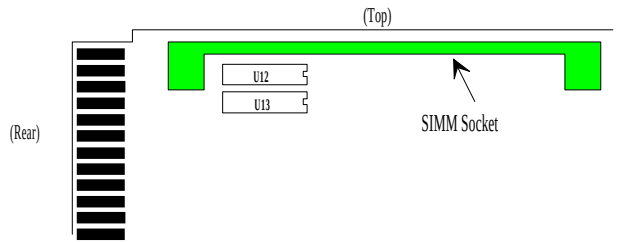


Figure 1: Base Memory Chip Location

For systems with 1 Mbyte of base memory, the memory technology is 4Mbit chips organized as two 256K by 18-bit banks. This base memory configuration can be identified on the board by examining the memory chips and the corresponding pads. The circuit board provides 42 pads per chip but the chips are 40-pin. Therefore the rear-most pads are not used.

For systems with 4 MBytes of base memory, the memory technology is 16Mbit chips organized as two 1MB x 18-bit banks. As with the 1 MByte system, identifying this memory configuration requires looking closely at the rear pads at location U12 and/or U13. All pads are used for this memory configuration.

Memory Expansion

In addition to the base memory, a single 72-pin SIMM socket is provided for memory expansion. SIMM memory occupies banks 2 and 3. Any standard SIMM module may be used that meets the following criteria:

- fast page mode
- 72-pin
- 80 nanosecond DRAM
- single-sided
- one- or two-bank

Allowable system memory configurations and the specifics of which SIMM to use are dependent on the system base memory. The tables below specify the correct SIMM module for each possible configuration.

For 1 Mbyte of base memory

Total Memory	SIMM Memory	SIMM organization
1 MB	None	
3 MB	2 MB	1 bank 1 MB x 18-bit
5 MB	4 MB	2 banks 1 MB x 18-bit
9 MB	8 MB	1 bank 4 MB x 18-bit

For 4 Mbytes of base memory

Total Memory	SIMM Memory	SIMM organization
4 MB	None	
6 MB	2 MB	1 bank 1 MB x 18-bit
8 MB	4 MB	2 banks 1 MB x 18-bit
12 MB	8 MB	1 bank 4 MB x 18-bit
20 MB	16 MB	2 bank 4 MB x 18-bit

Memory Map

The Intel386 SL supports a 25-bit physical memory address. Memory at addresses between 0 and 20 MB (13FFFFFh) is mapped as follows:

Range	Content
0000000 - 009FFFF	DRAM (first 640 KB)
00A0000 - 00BFFFF	mapped to EXM expansion interface; almost always used by a video controller as video RAM
00C0000 - 00CFFFF*	Write-protected DRAM containing video BIOS
00D0000 - 00EFFFF*	Uncommitted; mapped to EXM expansion interface
00F0000 - 00FFFFF	Write-protected DRAM containing BIOS
0100000 - 13FFFFF	Extended Memory when installed or mapped to EXM expansion interface
1400000 - 1FEFFFF	Mapped to EXM expansion interface
1FF0000 - 1FFFFFF	Mapped to BIOS ROM

***** 0C8000 - 0EFFFF may be used either as page frame or I/O buffer (i.e. for EMM, Ethernet, etc.) or may be used by DOS 5.0 as upper memory blocks if an EMM driver is installed.

Note that since the EXM expansion interface has 24 address lines, some of the "mapped to EXM expansion interface" address areas map repeatedly, or wrap-around, in the expansion interface's address space.

3 3

Cache (EPC-22 only)

The cache is a 64 KB four-way set-associative cache. This is a write-through cache, meaning that memory writes from the 386SL that hit the cache (find the addressed location in the cache) also write into the DRAM.

Addresses from 0 to 640K are cached. Addresses from 640K to 1M are not cached. Addresses from 1M to the top of installed memory are cached with the exception of a secondary graphics frame buffer such as is used on the EXM-14 Live video board.

ROM and ROM Shadowing

The EPC contains a BIOS EPROM that is mapped into the top of the processor's 25-bit address space. The EPROM contains the PC BIOS, self test functions, and the setup screen program.

For best possible performance, the BIOS initialization software copies the ROM contents into DRAM (called shadowing) at addresses 0F0000-0FFFFF (also called the "F" page). The BIOS also searches for the existence of a video adapter containing a video BIOS. If a video BIOS is found, it is copied into the 0Cxxxx ("C" page) area of DRAM.

After copying into these areas, the BIOS write-protects them. Subsequent writes to these areas complete successfully but do not alter the data.

Battery

The battery powers the CMOS RAM and Time of Day clock when system power is not present. At 60°C, the battery should have a shelf life of over four years. In a system that is powered on much of the time and where the ambient power-off temperature is less than 60°C, the battery is estimated to have a life of 10 years.

The battery supplied with the EPC is a 23mm. 3V lithium "coin" battery or equivalent (e.g. Panasonic BR2330 or Rayovac BR2335). It is mounted on the component side of the circuit board near the bottom front corner. Should the battery fail, you may obtain and install a replacement. Figure 2 below illustrates how to change the battery.

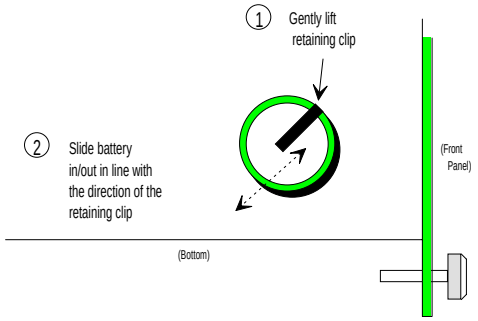


Figure 2: Battery Replacement

Replacing the battery is a simple task. However, removing the battery **will** invalidate the CMOS setup parameters. It is recommended that all setup parameters be recorded in a safe place while the battery is still good.

Video Controllers

The EPC can operate with or without a video controller (such as the EXM-6 or EXM-13). The BIOS searches for an EXM having an EXM ID in the range E8h-EFh (a range reserved for video controllers). The search is done by EXM slot number, beginning at slot 0. If no EXM video adapter is found, the BIOS will look for a PC add-in card with video BIOS. The CPU scans the memory space from A0000h to C8000h looking for any memory location containing the value AA55h. If such memory is found (add-in card BIOS ROM), the main BIOS will "jump" into the add-in card BIOS and execute whatever code is found.

In either case, the BIOS automatically initializes and uses the first one found.

If no video controller is present, the BIOS will operate without one. Programs that use the standard operating system and BIOS character output functions can be run successfully (the output is just ignored). However, programs that rely on specific video modes, that write directly into the video RAM, or that directly call video BIOS functions, will fail.

Front Panel LED

The EPC has one LED on the front panel. This RUN LED is lit whenever the EPC's memory is being accessed. It first comes on at power-up and should remain lit as long as the system is running. It is normal for the RUN LED to flicker during power-up. If the processor halts (or hangs) , the LED will go out.

3 3

Resetting the EPC

There are a number of ways to reset (reboot) the EPC.

Power-off, Power-on

> This causes the entire system to reset. The system will run the power-on self-tests and reboot the operating system.

Front-panel Reset button

> The Reset button causes the EPC to perform a hardware reset. The system will run the power-on self-tests and reboot the operating system.

Expansion Interface

> Pin A57 on the EXM expansion connector is defined as ~RESETIN. Asserting this input (low) will reset the processor. This is provided to allow remote reset to be implemented. This is a full hardware reset. The system will run the power-on self-tests and reboot the operating system.

Watchdog Timer

> Enabling the watchdog timer and allowing it to expire will reset the processor. The watchdog timer is tied to ~RESETIN pin described above. The system will run the power-on self-tests and reboot the operating system.

Setup Screen

> Pressing F10 and then F5 to save changes and reboot causes a full hardware reset.

CTRL+ALT+DEL

This keyboard sequence is called a "warm boot". The EPC does not reinitialize all of the processor's hardware. The power-on self-test does not run. However, the operating system will be reloaded. This type of reset typically only works under DOS.

Additional abnormal conditions that cause a reset

Low Vcc
No DRAM refresh signal from the micromonitor

EXM Expansion Interface

The EXM expansion interface is electrically similar to the PC/AT ISA (16-bit data) bus. The expansion interface is provided on both sides of the edge connector on the rear of the EPC. See Chapter 4, *Connectors* for details of the signals provided.

Watchdog Timer

The EPC-21 & 22 use the secondary 8254 timer in the 82360SL chipset to implement a watchdog timer function. Counter 2 within the 8254 is/should be programmed to reset the CPU when half of the timer's initial count has expired.

See Appendix B for details on programming the watchdog timer.

NOTES

3 3

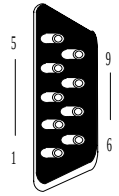
4. Connectors

This chapter specifies the details of the connectors on the EPC. These connectors adhere to existing standards. Pins are labeled from the point of view of looking into the front of the connector on the EPC.

Serial Ports

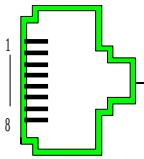
The COM1 serial port is a DB-9 DTE connector defined in the following table.

Pin	Signal	Pin	Signal
1	DCD	6	DSR
2	RxD	7	RTS
3	TxD	8	CTS
4	DTR	9	Ring indicator
5	Ground		



The COM2 serial port is a DTE RJ-45 phone jack connector defined in the following table:

RJ-45	Signal	DB25
1	Shield	1
2	CTS	4
3	TxD	3
4	DTR	8
5	RxD	2

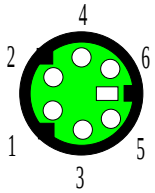


6	DCD	20	
7	Ground	7	
8	RTS	5	

Keyboard

The keyboard connector is a 6-pin DIN defined as

Pin	Signal	Pin	Signal
1	Data	4	+5V
2	not used	5	Clock
3	Ground	6	not used



EXM Expansion Connector

The EXM expansion connector on the rear of the EPC is a 116-pin cardedge connector. The mating connector is an AMP 650090-1 or equivalent. The connector pin numbers are divided into the A side and the B side. Pins A1 through A58 are on the component side of the board with pin A1 at the bottom of the board. Pins B1 through B58 are on the solder side of the board with pin B1 at the bottom of the board. The pin assignments are listed in the tables below followed by signal definitions.

A Row:

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	(unused)	A16	IRQ12	A31	-DACK3	A45	SA13
A2	(reserved)	A17	IRQ11	A32	-DACK2	A46	(key)
A3	+5V	A18	IRQ7	A33	(reserved)	A47	(key)
A4	+5V	A19	IRQ5	A34	-DACK1	A48	SA11
A5	SD15	A20	+5V	A35	-DACK0	A49	SA9
A6	SD13	A21	(reserved)	A36	-SBHE	A50	OSC
A7	SD11	A22	-IOCHK	A37	+5V	A51	SA7
A8	(unused)	A23	DRQ6	A38	AEN	A52	SA5
A9	SD9	A24	DRQ5	A39	SA23	A53	SA3

A10	SD7	A25	DRQ3	A40	SA21	A54	SA1
A11	SD5	A26	DRQ2	A41	SA19	A55	+5V
A12	(unused)	A27	DRQ1	A42	SA17	A56	+5V
A13	SD3	A28	DRQ0	A43	TC	A57	-RESETIN
A14	SD1	A29	-DACK6	A44	SA15	A58	(unused)
A15	IRQ15	A30	-DACK5				

B Row:

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
B1	GND	B16	GND	B31	-SMEMW	B45	SA12
B2	(reserved)	B17	IRQ9	B32	-SMEMR	B46	(key)
B3	GND	B18	IRQ6	B33	GND	B47	(key)
B4	GND	B19	IRQ4	B34	-MEMW	B48	SA10
B5	SD14	B20	IRQ3	B35	-MEMR	B49	SA8
B6	SD12	B21	-RSTDRV	B36	BALE	B50	GND
B7	SD10	B22	GND	B37	CLK	B51	SA6
B8	GND	B23	IOCHRDY	B38	GND	B52	SA4
B9	SD8	B24	-0WS	B39	SA22	B53	SA2
B10	SD6	B25	-IOCS16	B40	SA20	B54	SA0
B11	SD4	B26	-MEMCS16	B41	SA18	B55	GND
B12	GND	B27	-REFRESH	B42	SA16	B56	GND
B13	SD2	B28	GND	B43	GND	B57	-EXTSMI
B14	SD0	B29	-IOW	B44	SA14	B58	GND
B15	IRQ14	B30	-IOR				

EXM Expansion Connector Signals

The signal definitions below are listed in alphabetical order. Signal definitions preceded by a ⌖ are copied from the IBM AT Technical Reference Manual. Some liberties have been taken to correct the definitions for use with the Intel386 SL chip set and an 8 MHz bus speed.

⌖-0WS (I)

The 'zero wait state' signal tells the microprocessor that it can complete the present bus cycle without inserting any additional wait cycles. In order to run a memory cycle to a 16-bit device without wait cycles, 0WS is derived from an address decode gated with a Read or Write command. In order to run a memory cycle to an 8-bit

device with a minimum of two wait states, 0WS should be driven active one clock cycle after the Read or Write command is active, and gated with the address decode for the device. Memory Read and Write commands to an 8-bit device are active on the falling edge of CLK. 0WS is active low and should be driven with an open collector or tri-state driver capable of sinking 20 mA.

AEN (O)

The 'address enable' signal is used to de-gate the microprocessor and other devices from the I/O channel to allow DMA transfers to take place. When this line is active, the DMA controller has control of the address bus, the data-bus Read command lines (memory and I/O), and the Write command lines (memory and I/O). This signal is active high.

BALE (O) (buffered)

The 'buffered address latch enable' signal is provided by the Bus Controller and is used to latch valid addresses and memory decodes from the microprocessor. It is available to the I/O channel as an indicator of a valid microprocessor or DMA address (when used with 'address enable' signal, AEN). Microprocessor addresses SA0 through SA23 are latched with the falling edge of BALE. BALE is forced high (active) during DMA cycles.

CLK (O)

This is the 8-MHz system 'clock' signal. It is a synchronous microprocessor cycle clock with a cycle time of 125 nanoseconds. The clock has a 50% duty cycle. This signal should be used only for synchronization. It is not intended for uses requiring a fixed frequency.

-DACK0 through -DACK3, -DACK5, & -DACK6 (O)

-DMA acknowledge signals are used to acknowledge DMA requests. These signals are active low.

DRQ0 through DRQ3, DRQ5, DRQ6 (I)

The 'DMA request' signals are asynchronous channel requests used by peripheral devices and a microprocessor to gain DMA service (or control of the system). They

are prioritized, with DRQ0 having the highest priority and DRQ6 the lowest. A request is generated by bringing a DRQ line to an active (high) level. A DRQ line is held high until the corresponding 'DMA acknowledge' (DACK) line goes active. DRQ0 through DRQ3 perform 8-bit DMA transfers, DRQ5 and DRQ6 perform 16-bit transfers. DRQ4 is used on the system board and is not available on the I/O channel.

-EXTSMI (I)

System management interrupt. Non-maskable. This is the highest priority interrupt even taking priority over NMI. See the Intel386 SL Programming Reference for details. This is an active low signal.

-I/OCHK (I)

The 'I/O channel check' signal provides the system board with parity (error) information about memory or devices on the I/O channel. When this signal is active (low), it indicates a non-correctable system error.

-I/OCHRDY (I)

The 'I/O channel ready' signal is pulled low (not ready) by a memory or I/O device to lengthen I/O or memory cycles. Any slow device using this line should drive it low immediately upon detecting its valid address and a Read or Write command. Machine cycles are extended by an integral number of clock cycles (125 nanoseconds). This signal should be held low for no more than 2.5 microseconds.

-I/OCS16 (I)

The 'I/O 16-bit chip select' signal indicates to the system that the present data transfer is a 16-bit I/O cycle. It is derived from an address decode. -I/OCS16 is active low and should be driven with an open collector or tri-state driver capable of sinking 20 mA.

-IOR (I/O)

The '-I/O read' signal instructs an I/O device to drive its data onto the data bus. This signal may be driven by the system microprocessor or DMA controller, or by a microprocessor or DMA controller resident on the I/O channel. This signal is active low.

-IOW (I/O)

The '-I/O write' signal instructs an I/O device to read the data off the data bus. It may be driven by any microprocessor or DMA controller in the system. This signal is active low.

IRQ3 through IRQ7, IRQ9, IRQ11, IRQ12, IRQ14, & IRQ15 (I)

Interrupt requests 3 through 7, 9, 11, 12, 14, and 15 are used to signal the microprocessor that an I/O device needs attention. The interrupt requests are prioritized, with IRQ9, IRQ11, IRQ12, IRQ14 and IRQ15 having the highest priority (IRQ9 is the highest), and IRQ3 through IRQ7 having the lowest priority (IRQ7 is the lowest). An interrupt request is generated when an IRQ line is raised from low to high. The line is high until the microprocessor acknowledges the interrupt request (Interrupt service routine).

-MEMCS16 (I)

The '-memory 16-bit chip select' signal indicates to the system that the present data transfer is a 16-bit memory cycle. It must be derived from the decode of LA17 through LA23. -MEMCS16 is active low and should be driven with an open collector or tri-state driver capable of sinking 20 mA.

OSC (O)

The 'oscillator' signal is a high-speed clock with a 70-nanosecond period (14.31818 MHz). This signal is not synchronous with the system clock. It has a 50% duty cycle.

-REFRESH (I/O)

This signal is used to indicate a refresh cycle and can be driven by a microprocessor on the I/O channel. This signal is active low.

-RESETIN (I)

This signal is used to provide an external reset signal to the system. It is an active low signal.

-RSTDRV (O)

The 'reset drive' signal is used to reset or initialize system logic at power-up time or during a low voltage condition. This signal is active low.

SA0 through SA23 (I/O)

Address signals 0 through 23 are used to address memory and I/O devices within the system. These 24 address lines, in addition to LA17 through LA23, allow access of up to 16M of memory. SA0 through SA23 are gated on the system bus when 'buffered address latch enable' signal (BALE) is high and are latched on the falling edge of BALE. These signals are generated by the microprocessor or DMA controller. They also may be driven by other microprocessors or DMA controllers that reside on the I/O channel.

-SBHE (I/O)

The '-system bus high enable' signal indicates a transfer of data on the upper byte of the data bus, SD8 through SD15. 16-bit devices use -SBHE to condition data bus buffers tied to SD8 through SD15. This signal is active low.

SD0 through SD15 (I/O)

These signals provide bus bits 0 through 15 for the microprocessor, memory, and I/O devices. D0 is the least-significant bit and D15 is the most-significant bit. All 8-bit devices on the I/O channel should use D0 through D7 for communications to the microprocessor. The 16-bit devices will use D0 through D15. To support 8-bit devices, the data on D8 through D15 will be gated to D0 through D7 during 8-bit transfers to these devices; 16-bit microprocessor transfers to 8-bit devices will be converted to two 8-bit transfers.

-SMEMR (O) -MEMR (I/O)

These signals instruct the memory devices to drive data onto the data bus. -SMEMR is active only when the memory decode is within the low 1M of memory space. -MEMR is active on all memory read cycles. -MEMR may be driven by any microprocessor or DMA controller in the system. -SMEMR is derived from -MEMR and the decode of the low 1M of memory. When a microprocessor on the I/O channel wishes to drive -MEMR, it must have the address lines valid on the bus for one clock cycle before driving -MEMR active. Both signals are active low.

-SMEMW (O) -MEMW (I/O)

These signals instruct the memory devices to store the data present on the data bus. -SMEMW is active only when the memory decode is within the low 1M of the memory space. -MEMW is active on all memory write cycles. -MEMW may be driven by any microprocessor or DMA controller in the system. -SMEMW is derived from -MEMW and the decode of the low 1M of memory. When a microprocessor on the I/O channel wishes to drive -MEMW, it must have the address lines valid on the bus for one clock cycle before driving -MEMW active. Both signals are active low.

TC (O)

The 'terminal count' signal provides a high pulse when the terminal count for any DMA channel is reached.

5. Troubleshooting & Error Messages

Troubleshooting

This section deals with problems that you may encounter that do not provide an error message. If an error message is displayed, see the next section of this chapter, *Common Error Messages*.

Symptoms	Possible cause(s)	Solution
System appears to boot (evidenced by RUN LED being on, floppy and/or hard disk being accessed) but provides no video.	Video adapter not fully seated.	Remove the video adapter. Reinsert the video adapter and verify proper seating of the edge connector.
	Monitor or cable problem.	Verify that the cable pins are not bent and the cable is fully seated in the video adapter. If necessary, try the monitor on another system to verify that the monitor is good.
	Video adapter failure.	Replace video adapter.
	EPC cannot talk to EXM expansion interface.	Verify that the EPC is fully seated in the edge connector.
System fails at power-up - will not run power-on self-test.	The system is not getting power.	Verify that +5V power is good and that the EPC is fully seated.
	Hardware failure.	Replace the EPC.

Symptoms	Possible cause(s)	Solution
Serial port(s) do not work.	Port is disabled in the Setup screen.	Press CTRL+ALT+ESC to enter the Setup screen. Use cursor arrows to move to the appropriate field and toggle the entry to enable the port.
	Interrupt conflicts.	Another module may be using the same interrupts as COM1 and/or COM2. Verify that no other card in system is using IRQ3 or IRQ4.
	Port hardware failure.	Replace the EPC.

Common Error Messages

This section contains a summary of error and warning messages alphabetized by message text. These are messages generated by the BIOS and MS-DOS that may be related to your hardware configuration.

BAD OR MISSING COMMAND INTERPRETER DOS

Problem: The DOS operating system cannot find the Command line interpreter.

Solution(s): Either COMMAND.COM is not present at the specified (or default) directory level of the boot disk or the "SHELL=" statement in your CONFIG.SYS lists the file incorrectly (wrong directory or misspelled).

CMOS CHECKSUM INVALID BIOS

Problem: Something in the CMOS RAM is incorrect.

Solution(s): Run the BIOS setup program to determine what is wrong, and correct it. If the error occurs repeatedly, the EPC's battery has failed.

CMOS RAM ERROR, CHECK BATTERY / RUN SETUP BIOS

Problem: Something in the CMOS RAM is incorrect.

Solution(s): Run the BIOS setup program to determine what is wrong, and correct it. If the error occurs repeatedly, the EPC's battery has failed.

DISK BOOT FAILURE, INSERT SYSTEM DISK AND PRESS ENTER BIOS

Problem: No boot disk could be found.

Solution(s): This could occur in several different ways.

Your hard disk may not have been partitioned into logical drive(s). PCs look for logical drives to boot from. Hard disks are physical drives; partitions are logical drives.

If your BIOS setup screen has all disks disabled, or if your hard disk is disabled and no floppy diskette is inserted in the A: drive. Run the BIOS setup program and verify that all disk parameters are correct. If they are, insert a bootable floppy disk in the A: drive and press enter. If a hard disk is present, verify that it is properly partitioned and formatted as a system disk and one partition is set active.

DISKETTE DRIVES OR TYPES MISMATCH ERROR - RUN SETUP BIOS

Problem: The floppy diskette(s) installed in the system do not match the configuration information listed in the BIOS setup screen. This may be due to incorrect entries in the BIOS setup screen or one or both drives may not be responding at power-up.

Solution(s): Press CTRL+ALT+ESC to run the BIOS setup program. Make sure the BIOS setup entries relating to floppy drives correctly reflect the attached floppy drives. If you have no floppy drives, both drive A and drive B should be set to none.

Also, verify that all floppy drives are firmly connected (via ribbon cable) and that each drive has power. If the floppy drive is getting power through the ribbon cable, make sure that the appropriate jumpers are set correctly.

ERROR INITIALIZING HARD DISK 0 BIOS

Problem: The IDE disk controller for drive C cannot be initialized.

Solution(s): Ensure that the +5V power to the controller and hard disk are good and, if used, the ribbon cable to the hard disk is fully seated.

If you are not using an IDE drive, press CTRL+ALT+ESC to enter the BIOS setup program. Press F3 to enter the Fixed disk menu. Change the drive type to match the device being used.

EXM CONFIGURATION ERROR BIOS

Problem: The EXMs installed (or not installed) do not match the configuration information in the BIOS setup EXM menu.

Solution(s): Press CTRL+ALT+ESC to run the BIOS setup program. Press F2 to enter the EXM menu. Verify the information listed on the screen, save any changes and reboot.

If necessary, refer to the section *EXM Setup Screen*, page 6 of this manual and/or your EXM manual(s) for more details.

FLOPPY DISK CNTRLR ERROR OR NO CNTRLR PRESENT BIOS

Problem: The configuration information in the BIOS setup says that one or more floppy disk drives are expected, but a floppy disk controller could not be found.

Solution(s): If you have no floppy diskette drives, press CTRL+ALT+ESC to enter the setup program and set both floppy drives to "NONE."

If you are using a floppy drive(s), verify that both the floppy controller and the floppy drive(s) have power.

GENERAL FAILURE READING DRIVE ... DOS

Problem: This almost always indicates the presence of an unformatted hard disk partition or diskette.

Solution(s): Format the partition or diskette using the utilities supplies by your operating system.

INVALID DRIVE SPECIFICATION DOS

Problem: You are trying to access a logical drive (e.g., A:, B:, ...) that is not known to the operating system.

Solution(s): Select a different logical drive. If you are trying to access a hard disk, you may need to create the logical partition.

KEYBOARD ERROR OR NO KEYBOARD PRESENT BIOS

Problem: This message indicates that the system did not recognize a keyboard at power-up or you pressed a key during the power-on self test.

Solution(s): Check the integrity of the keyboard connector.

If you think you pressed a key during power-up, reboot the system using the front panel reset button.

Some keyboards are designed with a switch (or jumper) to allow the user to configure the keyboard for use with an AT machine or an XT machine. If this is the case with your keyboard, verify that the switch is in the AT position.

The keyboard may not be a valid PC/AT keyboard (e.g., it is a PC/XT-only or PS/2 keyboard). If this is the case, replace the keyboard with a PC/AT style keyboard.

MEMORY PARITY INTERRUPT AT ... BIOS

Problem: This could be a software error (reading a nonexistent memory area) or a true hardware failure.

Solution(s): Attempt to repeat the error. If the error occurs during the execution of your own proprietary software, verify that the memory location specified in your software is valid.

MISSING OPERATING SYSTEM BIOS

Problem: Although the system could read the hard disk and find the active partition, the operating system files could not be found.

Solution(s): This can be caused by using a drive type number in the BIOS setup Fixed Disk menu that does not match the type number used to format the hard disk. Press CTRL+ALT+ESC to run the BIOS setup program. Press F3 to enter the Fixed Disk menu. Select the correct drive type to match the type used to format the disk originally. Save the changes and reboot the system.

This can also occur if the hard disk is partitioned and one partition is set active, but the partition is not formatted.

NON-SYSTEM DISK OR DISK ERROR BIOS
REPLACE AND PRESS ANY KEY WHEN READY

Problem: This is caused by an attempt to boot from a disk or diskette that is not recognized as a system disk; that is no system files exist on the disk or diskette.

Solution(s): Most often it results when you reboot with a non-system diskette in the floppy drive, because the BIOS always attempts to boot from the floppy drive if a diskette is installed.

If you are trying to boot from the hard disk, make sure that you do not have a diskette in drive A and press any key.

If you are trying to boot from floppy, insert a known good bootable system diskette in drive A and press any key.

NOT READY READING DRIVE ... DOS

Problem: This is usually caused by not fully inserting a diskette into the floppy drive.

Solution(s): Eject the floppy diskette and reinsert making sure that the diskette seats completely into the floppy drive.

PARITY ERROR IN SEGMENT ... DOS

Problem: This could be a software error (reading a nonexistent memory area) or a true hardware failure.

Solution(s): Attempt to repeat the error. If the error occurs during the execution of your own proprietary software, verify that the memory location specified in your software is valid.

PRESS A KEY TO REBOOT BIOS

Problem: A C: drive partition exists but is not set active.

Solution(s): Run your operating system disk partitioning program (like FDISK) and set the primary partition active.

REAL TIME CLOCK ERROR - RUN SETUP BIOS

Problem: The battery-backed TOD clock is incorrect.

Solution(s): Run the BIOS setup program to determine what is wrong, and correct it. If the error occurs repeatedly, the EPC's battery has failed.

You should attempt to solve the problem yourself. If you are unable to solve the problem, please call RadiSys Technical Support.

NOTES

6. Support and Service

In North America

Technical Support

RadiSys maintains a technical support phone line at (503) 646-1800 that is staffed weekdays (except holidays) between 8 AM and 5 PM Pacific time. If you have a problem outside these hours, you can leave a message on voice-mail using the same phone number. You can also request help via electronic mail or by FAX addressed to RadiSys Technical Support. The RadiSys FAX number is (503) 646-1850. The RadiSys E-mail address on Internet is support@radisys.com. If you are sending E-mail or a FAX, please include information on both the hardware and software being used and a detailed description of the problem, specifically how the problem can be reproduced. We will respond by E-mail, phone or FAX by the next business day.

Technical Support Services are designed for customers who have purchased their products from RadiSys or a sales representative. If your RadiSys product is part of a piece of OEM equipment, or was integrated by someone else as part of a system, support will be better provided by the OEM or system vendor that did the integration and understands the final product and environment.

Bulletin Board

RadiSys operates an electronic bulletin board (BBS) 24 hours per day to provide access to the latest drivers, software updates and other information. The bulletin

board is not monitored regularly, so if you need a fast response please use the telephone or FAX numbers listed above.

The BBS operates at up to 14400 baud. Connect using standard settings of eight data bits, no parity, and one stop bit (8, N, 1). The telephone number is (503) 646-8290.

Repair Services

Factory Repair Service is provided for all RadiSys products. Standard service for all RadiSys products covers factory repair with customers paying shipping to the factory and RadiSys paying for return shipment. Overnight return shipment is available at customer expense. Normal turn-around time for repair and re-certification is five working days.

Quick Exchange services (immediate shipment of a loaner unit while the failed product is being repaired) or other extra-cost services can be arranged, but need to be negotiated in advance to allow RadiSys to pool the correct product configurations. RadiSys does not maintain a general "loaner" pool: units are available only for customers that have negotiated this service in advance.

RadiSys does not provide a fixed-price "swap-out" repair service, as customers have indicated that issues of serial number tracking and version control make it more convenient to receive their original products back after repair.

Warranty Repairs

Products under warranty (see warranty information in the front of this manual) will have manufacturing defects repaired at no charge. Products sent in for warranty repair that have no faults will be subject to a recertification charge. Extended Warranties are available and can be purchased at a standard price for any product still under warranty. RadiSys will gladly quote prices for Extended Warranties on products whose warranties have lapsed; contact the factory if this applies.

Customer induced damage (resulting from misuse, abuse, or exceeding the product specifications) is not covered by the standard product warranty.

Non-Warranty Services

There are several classes of non-warranty service. These include repair of customer induced problems, repairs of failures for products outside the warranty period, recertification (functional testing) of a product either in or out of warranty, and procurement of spare parts.

All non-warranty repairs are subject to service charges. RadiSys has determined that pricing repairs based on time and materials is more cost-effective for the customer than a flat-rate repair charge. When product is received, it will be analyzed and, if appropriate, a cost estimate will be communicated to the customer for authorization. After the customer authorizes the repair and billing arrangements have been made, the product will be repaired and returned to the customer.

A recertification service is provided for products either in or out of warranty. This service will verify correct operation of a product by inspection and testing of the product with standard manufacturing tests. There is a product-dependent charge for recertification.

There are only a few components that are generally considered field-repairable, but, because RadiSys understands that some customers want or need the option of repairing their own equipment, all components are available in a spares program. There is a minimum billing charge associated with this program.

6 6

Arranging Service

To schedule service for a product, please call RadiSys Technical Support directly at (503) 646-1800. Have the product model and serial numbers available, along with a description of the problem. A Technical Support representative will issue a Returned Materials Authorization (RMA) number, a code number by which we track the product while it is being processed. Once you have received the RMA number, follow the instructions of the Technical Support representative and return the product to us, freight prepaid, with the RMA number clearly marked on the exterior of the package. If possible re-use the original shipping containers and packaging. In any case, be sure you follow good ESD-control practices when handling the product, and ensure that anti-static bags and packing materials with adequate padding and shock-absorbing properties are used.

Ship the product, freight prepaid, to

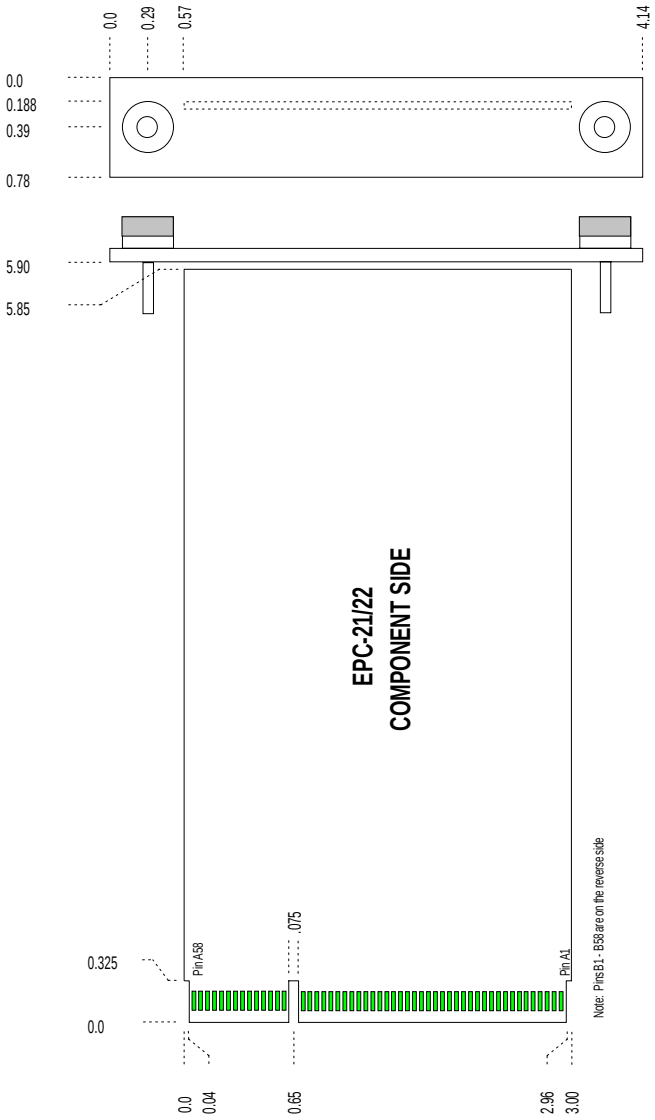
Product Service Center
RadiSys Corporation
15025 SW Koll Parkway
Beaverton, Oregon 97006-6902

When shipping the product, include the following information: return address, contact names and phone numbers in purchasing and engineering, and a description of the suspected problem. Any ancillary information that might be helpful with the debugging process will be appreciated.

Other Countries

Contact the sales organization from which you purchased your RadiSys product for service and support.

Appendix A: EPC Mechanical Dimensions



A A

NOTES

Appendix B: Programming the Watchdog Timer

B B

Programming the timer requires entry into the 82360SL configuration space. This configuration space is enabled by performing four sequential reads to the following I/O addresses : 0FC23H, 0F023h, 0C023h and 0023h. When enabled access to the registers within is controlled by two 8-bit read/write registers: the Configuration Index Register, CFGINDEX (24h) and the Configuration Data Register, CFGDATA (25h). The CFGINDEX register stores the index of the register to be accessed and the CFGDATA register stores the data.

The code segment below is a Microsoft C for DOS example of how to enable the 82360SL configuration space:

```
unsigned short
saveflags()
   {
        unsigned short flags;

        ASM
           pushf
           pop   flags
        ENDASM
        return flags;
   }

unsigned short
enablespace()
   {
        unsigned short flags;

        flags = saveflags();
        _disable();
        (void) inp(0xFC23);
        (void) inp(0xF023);
        (void) inp(0xC023);
        (void) inp(0x0023);
        return flags;
   }
```

The 82360SL configuration space is disabled by setting the Lock bit (bit 0) of the Configuration Lock Register. Calling the `disablespace` function below with the processor flags value returned from the `enablespace` function disables the configuration space and restores the system flags to the state prior to the call of `enablespace`.

```
void
restoreflags(unsigned short flags)
   {
        ASM
           push  flags
           popf
       ENDASM
   }

void
disablespace(unsigned short flags)
   {
        outp(CFGINDEX,0xfa);
        outp(CFGDATA,0x01);
        restoreflags(flags);
   }
```

Once the 82360SL configuration space is visible, the reset enable, timer command and timeout value can be programmed. The reset enable is active when bit 0 of the SMOUTCNTRL (index 0xFE) register is cleared (0). Clearing this bit will cause a PC reset when half of the timer count programmed into the T2CH2CNT has expired.

The watchdog timer's maximum timeout is 491 milliseconds. This is derived by multiplying the maximum tick count 65535 (0xFFFF) by the clock frequency (15 microseconds), and then dividing by 2 since the PC is reset when half of the count has expired.

Using the watchdog timer function requires the installation of a driver that reprograms the watchdog timer value before half the initial timeout count expires.

This is typically done by chaining the PC timer interrupt and reprogramming the watchdog timer count within the timeout period.

Listed below is a complete program that implements a watchdog timer function.

The watchdog timer is programmed to reset the PC at 491 milliseconds.

```
#include <dos.h>
#define ASM                     _asm {
#define ENDASM                  }
#define INTERRUPT               _interrupt
#define CFGINDEX                0x24  /* configuration space index */
#define CFGDATA                 0x25  /*    configuration    space    data
address */
#define T2COMMAND               0x83  /* timer 2 command address */
```

```
#define T2CH2CNT                0x82  /* timer 2 counter address */
#define TIMER2CW                0xb6  /*  counter  2,  write,  mode  3,  bin
*/
#define TIMERTICKRESOLUTION     15    /*  Timer  has  15  microsecond  tick
*/
#define TIMERINT                8     /* PC timer interrupt vector */
#define TIMER2TICKS             0xffff       /* ~491 milliseconds
*/
#define SMOUTCTRL               0xfe  /* reset enable latch      */
void (INTERRUPT *previoustimerfunction)();
volatile unsigned long Tick = 0;
#pragma intrinsic(_disable,_enable,inp,inpw,outp,outpw)

unsigned char
getconfigurationregister(unsigned short slregister)
   {
        outp(CFGINDEX,slregister);
        return ((unsigned char) inp(CFGDATA));
   }
void
setconfigurationregister(unsigned    short    slregister,unsigned    char
slvalue)
   {
        outp(CFGINDEX,slregister);
        outp(CFGDATA,slvalue);
   }
unsigned short
saveflags()
   {
        unsigned short flags;

       ASM
          pushf
          pop   flags
        ENDASM
        return  flags;
   }
void
restoreflags(unsigned short flags)
   {
        ASM
          push   flags
          popf
        ENDASM
   }
unsigned short
enablespace()
   {
        unsigned short flags;
            /*
            // Any interrupt that occurs between saveflags & disable
            // should restore  the  flag  register  (via  the  iret).
            // Therefore, the flags variable is guaranteed to contain a
            // copy of the machines state prior to   disabling
            // interrupts.
            */
        flags = saveflags();
        _disable();
            /*
```

B B

```
            // The 82360SL configuration space is enabled by performing
            // four sequential reads to the addresses listed below.
            */
        (void) inp(0xFC23);
        (void) inp(0xF023);
        (void) inp(0xC023);
        (void) inp(0x0023);
        return flags;
    }
void
disablespace(unsigned short flags)
    {
        outp(CFGINDEX,0xFA);
        outp(CFGDATA,0x01);
        restoreflags(flags);
    }
void
refreshtimer()
    {
        setconfigurationregister(T2COMMAND,TIMER2CW);
        setconfigurationregister(T2CH2CNT,TIMER2TICKS & 0xFF);
        setconfigurationregister(T2CH2CNT,TIMER2TICKS >> 8);
    }

void INTERRUPT
mytimer()
    {
        unsigned short flags;

        if (Tick == 0)
           {
              flags = enablespace();
              refreshtimer();
              disablespace(flags);
                 /*
                 // The PC timer executes at 54 millisecond intervals or
                 // 18.2 times a second.  The Watchdog timer must be
                 // refreshed within half the timeout period specified in
                 // the count register [(65535ticks / 2) * 15us / 1000ms
                 // = 491ms]
                 */
              Tick = (unsigned short)
                 ((long) TIMER2TICKS / 2L * (long) TIMERTICKRESOLUTION /
                  1000L / 54L) - 1;
           }
        Tick--;
        _chain_intr(previoustimerfunction);
    }
/*
//      This procedure chains the DOS timer interrupt and turns on the
//      watchdog timer.  The chained DOS timer handler reprograms the
//      watchdog timer with the initial count.
*/
void
installtimer(void (INTERRUPT *newfunction)())
    {
        unsigned short flags;
        _disable();
        previoustimerfunction = _dos_getvect(TIMERINT);
```

```
        flags = enablespace();
        refreshtimer();
        setconfigurationregister(SMOUTCTRL,
          (unsigned char)(getconfigurationregister(SMOUTCTRL) &
          (unsigned char)~1));
        disablespace(flags);
        _dos_setvect(TIMERINT,newfunction);
        _enable();
    }
void
deinstalltimer()
    {
        unsigned short flags;
        flags = enablespace();
        setconfigurationregister(SMOUTCTRL,
          (unsigned char) (getconfigurationregister(SMOUTCTRL) | 1));
        _dos_setvect(TIMERINT,previoustimerfunction);
        disablespace(flags);
    }
main(int argc, char **argv)
    {
        unsigned short flags;
        installtimer(mytimer);
          /*
          //   Application code goes here ...
          */
        deinstalltimer();
    }
```

For more details see the Intel 8254 specification and the *Intel 386 SL Microprocessor Superset Programmer's Reference Manual.*

NOTES